Center Independent Research & Development: GSFC IRAD

Efficient Radiation Shielding Through Direct Metal Laser Sintering

Completed Technology Project (2012 - 2014)

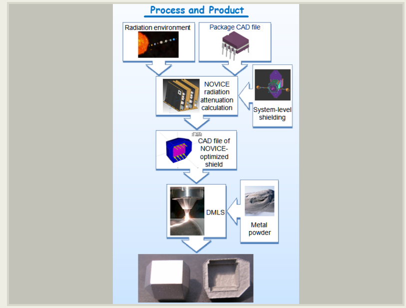
Project Introduction

We have developed a method for efficient component-level radiation shielding that can be printed by direct metal laser sintering (DMLS) from files generated by the commercial Monte-Carlo particle transport code, NOVICE, modified for this purpose. The development of techniques for 3-D printing of otherwise difficult-to-fabricate shielding designs will reduce infusion risk of new electronics technology by providing a mass- and cost-efficient, effective mitigation of risks due to total ionizing dose. This component-level spot shielding technology readiness level is being raised through mechanical, thermal, and vibration testing and analysis of the complete shield-component-printed circuit board (PCB) system.

Functional and parametric degradation of microcircuits due to total ionizing dose (TID) often pose serious obstacles to deployment of critical state-of-the-art (SOTA) technologies in NASA missions. Shielding to the electronics box is used to mitigate TID degradation. Shielding materials can add significant amounts of mass to a system. One method for reducing mass is to apply “spot” shielding located only on the critical components that require it. Board area is often a constraint for spot shield design. 3-D printing technology offers promising breakthroughs in the design and deployment of radiation shielding optimized to the capability of the component, the mission radiation environment, and the shielding already provided by the component’s surroundings. Shields can be designed based upon the individualized package features to minimize area yet better protect from the omnidirectional radiation environment; such hand-and-glove fits would otherwise require complex machining.

Shield design is accomplished by the commercially-available NOVICE code. NOVICE radiation attenuation calculations use the code’s ray-trace procedure in conjunction with 1-D attenuation data scaled for the different attenuation properties of the materials. A 3-D adjoint Monte-Carlo simulation verifies shielding effectiveness. NOVICE then generates the .STL CAD file for direct importation into a DMLS system.

We have demonstrated successful development, fabrication, and mass-savings of a DMLS additive-manufactured component-level prototype shield. The prototype shield was assembled to a PCB-mounted operational amplifier as a proof-of-concept and for Phase II functional evaluation necessary to bring this technology to TRL-6. Phase II efforts focus on environmental (vibration, thermal-vacuum) testing of the shield-component-PCB system. Additional goals include demonstration of reliable DMLS-printed shield design and fit across package types, and assessment of the manufacturing quality of the DMLS-printed shields across multiple manufacturers and materials.



Flowchart of component shielding methodology (bottom portion of shield not shown). Final shield design accounts for collateral shielding available.

Table of Contents

Anticipated Benefits

- Reduce mass of electronics boxes for long-duration missions;
- Expand list of suitable electronic parts.

- Reduce mass of electronics boxes in harsh radiation environment missions such as those flying in the radiation belts of Earth and Jupiter;
- Reduce mass of electronics boxes in long-duration missions;
- Enable use of electronic parts that would otherwise fail to meet mission total-ionizing dose requirements;
- Increase the mission lifetime of small-satellites which offer minimal collateral shielding.

- Enable use of electronic parts that would otherwise fail to meet mission total-ionizing dose requirements;
- Reduce mass of electronics boxes and/or increase mission lifetimes.
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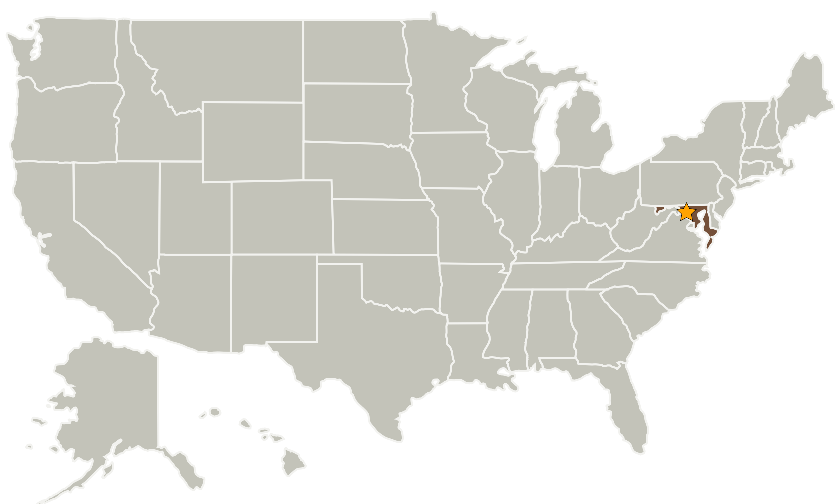
Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Center Independent Research & Development: GSFC IRAD

Project Management

Program Manager:

Peter M Hughes

Project Manager:

Wesley A Powell

Principal Investigator:

Jean-marie Lauenstein

Co-Investigators:

Raymond L Ladbury
Allison L Evans
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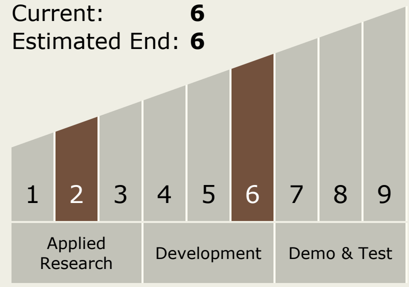
Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland

Co-Funding Partners	Type	Location
Experimental and Mathematical Physics Consultants(EMPC)	Industry	

Primary U.S. Work Locations
Maryland

Technology Maturity (TRL)

Start: **2**
Current: **6**
Estimated End: **6**

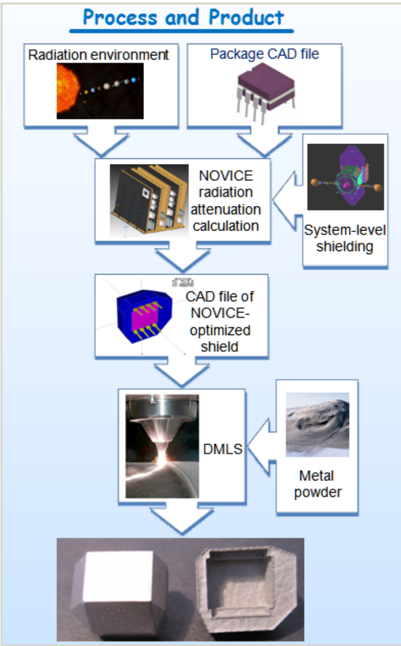


Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  - └ TX06.5 Radiation
    - └ TX06.5.3 Protection Systems

Images



Radiation Shielding through DMLS: Process and Product
Flowchart of component shielding methodology (bottom portion of shield not shown). Final shield design accounts for collateral shielding available.
(https://techport.nasa.gov/image/2735)

Stories

Goddard's Storied Tradition Potentially Expanded Through 3D Manufacturing
(https://techport.nasa.gov/file/1298)

Links

NTR 1
(no url provided)

Project Website:

http://sciences.gsfc.nasa.gov/sed/